EAS 4305/6305 Physics and Chemistry of the Oceans
Homework #7: Due before class, November 8th

Primary Production

Vertical structure of primary productivity at HOT

Download the data file (http://shadow.eas.gatech.edu/~Ito/webdata/courses/EAS6305/hot_pp.txt). It contains the chlorophyll and ^{14}C incubation productivity in text format. The data is originally downloaded from the Hawaii Ocean Timeseries (HOT) station. There are six columns containing (1) cruise number, (2) date (YYMMDD), (3) pressure (dbar), (4) chlorophyll-a concentration (mg m^{-3}), (5) 12 hour ^{14}C incubation productivity with light (mgC m^{-3}), and (6) 12 hour ^{14}C incubation productivity in dark (mgC m^{-3}). Missing data is set to -9. Most of the measurements are taken at standard depths of 5, 25, 45, 75, 100, 125, 150 and 175m. To read the data in MATLAB, use the "load" command.

(1) Obtain the mean vertical profile of chlorophyll-a by averaging all available data at the standard depths. Make a plot of the mean vertical profile.

(2) What is the depth of the deep chlorophyll maximum?

(3) Calculate NPP (mgC m^{-3} day^{-1}) by adding the 12-hour ^{14}C incubation productivity from light and dark conditions. Then, plot the mean vertical profile of NPP by averaging all available data at each standard depth level. Make a plot of the mean vertical profile of NPP.

(4) Compare and contrast the vertical structure of the NPP and chlorophyll-a.

(5) Estimate the vertically integrated NPP for the top 200m using the mean vertical profile from (4). The answer should be in the units of NPP (gC m^{-2} day^{-1}).

(6) The global ocean NPP is approximately 50 PgC/year (Pg = 10^{15}g). If this were uniformly distributed over the surface oceans, what would be the NPP per unit area (in units of gC m^{-2} day^{-1})? Compare this with your answer to (5).

(7) According to Redfield (1958), the stoichiometric ratio of bulk organic matter between P:N:C:O_2 is 1:16:106:-138. Note that this is molar ratio. For example, 1 mol of P in organic matter is associated with 106 mol of C. How much inorganic P (molP) and N (molN) are required to sustain the global NPP of 50 PgC/year?

(8) The upper 100m of the global ocean contains approximately 1,000 PgC of dissolved inorganic carbon, which about the same size as the atmospheric C inventory (800 PgC). Also, about 1/3 of the NPP is exported to thermocline and deep ocean as sinking organic particles. What would be the mean residence time

(MRT) of the upper ocean carbon reservoir with respect to this biological carbon export? What is the meaning of this MRT?